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(21) Application number	H4-296518	(71) Applicant	000001007 Canon Inc. 3-30-2 Shimomaruko, Ohta-ku, Tokyo	
(22) Date of application	October 9, 1992	(72) Inventor	Kazuo Takahashi Canon Inc. Kosugi Office 53 Imaikami-cho, Nakahara-ku, Kawasaki-shi, Kanagawa	
		(74) Representative	Tetsuya Ito, patent attorney (and one other party)	

(54) Title of Invention: IMMERSION TYPE PROJECTION EXPOSURE APPARATUS

(57) Abstract

Purpose: To provide an immersion type exposure apparatus that is able to utilize conventional process technology.

Constitution: A projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position; wherein the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

Scope of Patent Claims

Claim 1

An immersion type projection exposure apparatus; characterized in that, in a projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position, the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the



space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

Claim 2

An immersion type projection exposure apparatus described in Claim 1; characterized in that the positioning means is equipped with an alignment measurement means that detects the wafer position, a focus position detection means that detects the position of wafer exposure surface with respect to the focus position of the projection optical means, a wafer drive means that holds and drives the wafer in the X and Y directions parallel to the exposure surface thereof and also in the θ direction around the axis that is perpendicular to these, the Z direction, and in a direction in which the wafer is tilted toward the desired direction, and a wafer conveyance means that carries the wafer onto and out from the holding position of the wafer drive means.

Claim 3

An immersion type projection exposure apparatus described in Claim 2 in which the optical element that opposes the wafer is plane parallel glass.

Claim 4

An immersion type projection exposure apparatus described in Claim 2; characterized in that the projection optical means has a lens barrel, the optical element that opposes the wafer is attached to the lower end of that lens barrel, and a seal member is provided between that optical element and the lens barrel.

Claim 5

An immersion type projection exposure apparatus described in Claim 2; characterized in that the optical element that opposes the wafer can be moved in the optical axis direction thereof and positioned at the desired position.

Claim 6

An immersion type projection exposure apparatus described in Claim 2; characterized in that coated onto at least one of the flat surface or the protruding surface that protrudes toward the wafer side of the optical element that opposes the wafer and the exposure surface of the wafer is a coating material that has an affinity to the liquid used to fill the space between both of these surfaces.

Claim 7

An immersion type projection exposure apparatus described in Claim 2; characterized in that the upper surface of the liquid tank is released.

Claim 8

An immersion type projection exposure apparatus described in Claim 2; characterized in that the liquid tank forms a closed space.

Claim 9

An immersion type projection exposure apparatus described in Claim 8; characterized in that the liquid tank has a window for wafer transport that can be opened and closed.

Claim 10

An immersion type projection exposure apparatus described in Claim 8 in which the liquid tank forms a vacuum chamber.

Claim 11

An immersion type projection exposure apparatus described in Claim 8 that has a pressure gauge for detecting the pressure inside the liquid tank.



Claim 12

An immersion type projection exposure apparatus described in Claim 8 that has at least one of a pressurization means or a pressure reduction means for the liquid supplied inside the liquid tank.

Claim 13

An immersion type projection exposure apparatus described in Claim 8; characterized in that it has a pressurization means for the liquid inside the liquid tank.

Claim 14

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the liquid tank is positionally secured with respect to the optical means.

Claim 15

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions, which are parallel to the exposure surface thereof, and the drive means thereof, and the liquid tank is positionally secured to the XY stage.

Claim 16

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions, which are parallel to the exposure surface thereof, and the drive means thereof, and the drive portion of the XY stage is positioned outside the liquid tank.

Claim 17

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving the wafer in the X and Y directions and a fine movement stage that tilts the wafer in the desired direction, and the liquid tank is arranged on the XY stage.

Claim 18

An immersion type projection exposure apparatus described in Claim 17; characterized in that a fine movement stage is arranged inside the liquid tank, the liquid tank is formed by materials with high permeability, and the fine movement stage and the XY stage are magnetically linked via the liquid tank.

Claim 19

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the liquid tank is formed using a low heat expansion material.

Claim 20

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the positioning means has a means that detects the wafer position by means of a laser interferometer, and the liquid tank has a window for this laser interferometer.

Claim 21

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the positioning means has a means that detects the wafer position by means of a laser interferometer, and this laser interferometer is secured to the liquid tank.

Claim 22



An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that it is equipped with a liquid supply control means that supplies the liquid to the liquid tank and controls the amount and the level thereof.

Claim 23

An immersion type projection exposure apparatus described in Claim 22; characterized in that the liquid supply control means has a means that filters the supplied liquid.

Claim 24

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a means that excites the liquid that has filled the liquid tank.

Claim 25

An immersion type projection exposure apparatus described in Claim 14 or 15 that has a means that excites the wafer.

Claim 26

An immersion type projection exposure apparatus described in Claim 14 or 15 that has a means that excites the optical element that opposes the wafer.

Claim 27

An immersion type projection exposure apparatus described in Claim 25 or 26 in which the excitation means is an ultrasonic wave excitation apparatus.

Claim 28

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a temperature control means that measures and controls the temperature of the liquid supplied inside the tank.

Claim 29

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a refractive index measurement means that measures the refractive index of the liquid supplied inside the tank.

Claim 30

An immersion type projection exposure apparatus described in Claim 14 or 15 that is equipped with a stabilizer that inhibits fluctuation of the liquid supplied inside the tank.

Claim 31

An immersion type projection exposure apparatus described in Claim 14 or 15 in which the outer wall of the liquid tank is covered by a heat insulating member.

Claim 32

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means is equipped with a wafer chuck that uses suction to hold the wafer, and this wafer chuck has a conduit for performing suction holding by vacuum suction of the wafer and a shutter that prevents the liquid from flowing into this conduit.

Claim 33

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that the wafer drive means is equipped with a wafer conveyance means that carries the wafer in and out of the exposure position inside the liquid tank, and this wafer conveyance means is such that at least a portion is arranged inside the liquid tank.

Claim 34



An immersion type projection exposure apparatus described in Claim 33 in which the conveyance means has a means that transports the wafer vertically or at an angle to the liquid held inside the liquid tank and levels the wafer in the liquid.

Claim 35

An immersion type projection exposure apparatus described in Claim 33 in which the conveyance means is a means that subjects at least one side of the wafer to air flow when the wafer is transported from inside the liquid held in the liquid tank.

Claim 36

An immersion type projection exposure apparatus described in Claim 14 or 15; characterized in that it has a pump that supplies liquid to and drains it from the inside of the liquid tank. There is. [Translator's note: Apparent typo]

Claim 37

An immersion type projection exposure apparatus described in Claim 7 or 8; characterized in that the wafer drive means has an XY stage for moving in the X and Y directions and a fine movement stage that, through this, is moved in the X and Y directions and tilts the wafer in the desired direction, and the liquid tank is secured on the fine movement stage.

Claim 38

An immersion type projection exposure apparatus described in Claim 37; characterized in that the bottom surface of the liquid tank forms a wafer chuck that holds the wafer.

Claim 39

An immersion type projection exposure apparatus described in Claim 37; characterized in that at least two side surfaces of the liquid tank are formed by flat surfaces that are at right angles, and these flat surfaces form a laser light reflection surface.

Claim 40

An immersion type projection exposure apparatus described in Claim 18; characterized in that the bottom surface member of the liquid tank and the bottom surface of the fine movement stage form a flat surface guide of a hydraulic bearing.

Detailed Explanation of the Invention

[0001]

Industrial Field of Application

The present invention relates to an immersion type projection exposure apparatus for exposing a detailed circuit pattern on a wafer in the semiconductor manufacturing process.

[0002]

Prior Art

Miniaturization of semiconductor elements has progressed, and, conventionally, for exposure light sources, there has been a shift from the g-rays of high pressure mercury lamps to i-rays with shorter wavelengths. Therefore, since higher resolving power is necessary, the NA (numerical aperture) of the projection lens must be made larger, and for that reason, the trend is toward making the depth of focus increasingly shallow. As is generally well known, these relationships can be expressed by the following equations.

$$(\text{Resolving power}) = k_1 (\lambda/\text{NA})$$

$$(\text{Depth of focus}) = \pm k_2 / \text{NA}^2$$



Here,  $\lambda$  is the wavelength of the light source used in exposure, NA is the NA (numerical aperture) of the projection lens, and  $k_1$  and  $k_2$  are coefficients relating to processes.

[0003]

In recent years, the use of what are called excimer lasers (KrF, ArF) as well as x-rays, which have shorter wavelengths than the g-rays and i-rays of conventional high pressure mercury lamps, has also been studied. And, on the other hand, there has also been study of higher resolving power and higher depths through phase shift masks or deformation illumination, and practical application is beginning. However, the method of using what are called excimer lasers (KrF, ArF) and x-rays also has high equipment costs, and a phase shift mask or deformation illumination, etc. has problems such as there being cases in which effects cannot be expected depending on circuit patterns.

[0004]

Therefore, attempts to apply the immersion method have been made. For example, described in Examined Patent Application Publication No. 63-49893 is a configuration in which, in the exposure apparatus, a nozzle that has a liquid flow inlet surrounding the front end of a reduction lens is provided, liquid is supplied through this, and liquid is held between the reduction lens and the wafer.

[0005]

#### Problems to be Solved by the Invention

However, in this prior art, liquid is only supplied, and there are various problems in using it in the actual manufacturing process, such as it not being possible to utilize conventional process technology.

[0006]

The purpose of the present invention is to take the above problems of the prior art into account, provide an immersion type exposure apparatus that is low in cost and with which effectiveness corresponding to the respective wavelengths can be expected at any wavelength regardless of the wavelength of the exposure light source used, such as g-rays, i-rays or an excimer laser, and to provide an immersion type exposure apparatus that utilizes conventional process technology.

[0007]

#### Means to Solve Problems

In order to achieve this purpose, in the present invention, in a projection exposure apparatus equipped with an illumination means that illuminates a reticle, a projection optical means that projects the pattern on the reticle illuminated thereby onto a wafer, and a positioning means that positions the wafer at the prescribed position, the projection optical means is equipped with an optical element that is opposite the exposure surface of the wafer and has a flat surface or a protruding surface that protrudes toward the wafer side and a liquid tank for holding liquid that fills at least the space between the exposure surface of the wafer and the flat surface or the protruding surface of this optical element.

[0008]

The positioning means is normally equipped with an alignment measurement means that detects the wafer position, a focus position detection means that detects the position of the wafer exposure surface with respect to the focus position of the projection optical means, a wafer drive means that holds and drives the wafer in the X and Y directions, which are parallel to the exposure surface thereof, the  $\theta$  direction around an



axis that is perpendicular to these, the Z direction, and a direction in which the wafer is tilted in the desired direction, and a wafer conveyance means that carries the wafer onto and out from the holding position of the wafer drive means.

[0009]

There are also cases in which the liquid tank forms a closed space and has a pressurization means, etc. for the liquid inside the liquid tank. There are also cases in which the liquid tank is also positionally secured to the optical means or positionally secured to the XY stage. In the case in which the liquid tank is positionally secured to the optical means, for example, a fine movement stage is arranged inside the liquid tank, the liquid tank is formed by a material with high permeability, and the fine movement stage and the XY stage are magnetically bonded via the liquid tank.

[0010]

#### Actions

As a method of raising the resolving power of the optical system microscope, the so-called immersion method, which fills the space between the objective lens and the sample with a liquid with a high refractive index has been well-known (for example, D.W. Pohl, W. Denk & M. Lanz, Appl. Phys. Lett. 44652 (1984)). Examples of applying this effect to the transfer of the fine circuit patterns of semiconductor elements are "H.

Kawata, J.M. Carter, A. Yen, H.I. Smith, Microelectronic Engineering 9 (1989)" and "T.R. Corle, G.S. Kino, USP 5,121,256 (Jun. 9, 1992). Previous theses studied the effects of immersion in exposure, so configuration as an actual semiconductor exposure apparatus is not dealt with, and the latter patent does nothing more than disclose a method of placing an immersion lens near the surface of the wafer.

[0011]

The present invention relates to a specific method for using a production equipment projection exposure apparatus to realize a method of filling the space between the sample and the objective lens of a microscope with a liquid with a high refractive index, which has been known for a long time, and, through the present invention, an exposure apparatus that utilizes the immersion effect is provided.

[0012]

This "immersion effect" is such that when  $\lambda_0$  is considered the wavelength of the exposure light in the air, and, as shown in Fig. 10, n is the refractive index of the liquid used for immersion with respect to air,  $\alpha$  is the convergence half angle of the light beam, and  $NA_0 = \sin\alpha$ , when immersion is performed, the aforementioned resolving power and depth of focus are as in the following equations.

$$(\text{Resolving power}) = k_1 (\lambda_0/n)/NA_0$$

$$(\text{Depth of focus}) = \pm k_2 (\lambda_0/n)/(NA_0)^2.$$

That is, the immersion effect is an equivalent value to the wavelength using a 1/n exposure wavelength. In other words, in the case in which a projection exposure optical system with the same NA is used is designed, through immersion it is possible to make the depth of focus n times. This is effective for all of the various pattern shapes, and it is also possible to combine phase shift methods, deformation illumination methods, etc. that are currently being studied. In order to utilize this effect, accurate control of the purity, homogeneity, temperature, etc. of the liquid is necessary, and in exposure apparatuses that sequentially perform exposure onto the wafer using a step and repeat operation, making the liquid fluctuation and vibration generated during operation as small as



possible and the question of how to remove the foam that remains on the wafer surface when the wafer is carried into the liquid are problems. In the present invention, as explained in the embodiments, an apparatus configuration for solving these various problems is proposed, and the immersion effect is thoroughly utilized. Conventionally, in 256 Mbit to 1 Gbit DRAM production, it was thought that it was necessary [to move] from conventional steppers, which have i-rays or excimer lasers as light sources, to x-ray or electron beam (EB) exposure apparatuses, but through the present invention, it is possible to divert conventional manufacturing processes using conventional steppers that use i-rays or excimer lasers as light sources, and production that is also advantageous in terms of cost becomes possible due to technologically established manufacturing processes.

[0013]

This will be explained in more detail below by means of embodiments.

[0014]

Embodiments

Embodiment 1

Fig. 1 is a block diagram of an immersion type projection exposure apparatus relating to the first embodiment of the present invention. In the drawing, 1 is a reticle, 2 is a wafer that has been coated with a photosensitive material and to which the circuit pattern on the reticle 1 has been exposed and transferred, 3 is an illumination optical system that is equipped with a shutter, a light adjustment apparatus, etc. for projecting the circuit pattern on the reticle 1 onto the wafer 2, 4 is a projection optical system that projects the circuit pattern on the reticle 1 onto the wafer 2, 5 is a reticle stage for holding the reticle 1 and positioning it at the prescribed position, and 6 is an alignment optical system for matching the reticle image with the circuit pattern that has already been transferred onto the wafer 2 to position the reticle 1.

[0015]

If the lens that opposes the surface of the wafer 2 of the projection optical system 4 is called the second optical element 7, this surface that opposes the surface of the wafer 2 of the second optical element 7 is configured so that it is a flat surface or so that it protrudes toward the surface of the wafer 2 as shown in Fig. 2 and Fig. 3. This is to make it so that an air layer or foam does not remain on the surface of the second optical element 7 when immersion is performed. In addition, for the surface of the optical element 7 to be immersed and the surface of the photosensitive material on the wafer 2, it is preferable to implement coating that has an affinity to the liquid 30 used in immersion. There is a seal 8 between the second optical element 7 and the lens barrel of the projection optical system 4 for preventing penetration of the liquid 30 to the lens barrel. This seal is not necessary if the configuration is such that the second optical element 7 is made thick as shown in Fig. 4 and a function that controls the height of liquid 30 immersion is added.

[0016]

9 is a liquid tank (chamber) for filling with liquid 30, 10 is a wafer cassette, 11-1 through 11-4 are an apparatus for rough positioning of the wafer, 13 is an XY stage for positioning the wafer 2 at the prescribed position, and 14 is fine movement stage that is arranged on the XY stage and has a position compensation function for the  $\theta$  direction of the wafer 2, an adjustment function for the Z position of the wafer 2, and a tilt function



for compensating the tilt of the wafer 2. Within the chamber 9 are a wafer conveyance apparatus for carrying the wafer in from the wafer cassette 10 and setting it on the wafer chuck 12, part or the entirety of the rough positioning apparatus 11-1 – 11-4, a wafer chuck 12, an XY stage 13 and a fine movement stage 14.

[0017]

15 is a laser interferometer, 16 is a reference mirror that is attached in the X and Y directions (the Y direction is not shown in the drawing) on the fine movement stage 14 and reflects the light of the laser interferometer 15 to calculate the position of the fine movement stage 14, 17 is a window that is provided on the chamber 9 to allow the light of the laser interferometer 15 to pass through, 18 is a heat insulating material provided on the outside of the chamber 9 that maintains a heat shield with the outside. The chamber 9 itself is configured by a material that has a heat insulation effect, for example, engineering ceramics. In addition, a low heat expansion material, for example, Zerojoule (product name), is used for the material of the chamber 9, and, as shown in Fig. 5, it is also possible to directly attach the laser interferometer 15 to the side surface thereof so that the measurement precision of the laser interferometer 15 is not affected by the air index.

[0018]

The chamber 9 is also provided with a level gauge 19 for measuring the height of liquid 30, a temperature gauge 20 for measuring the temperature of the liquid 30, and a temperature controller 21. The chamber 9 is also provided with a pump 22 for controlling the height of the liquid 30. The pump 22 is also equipped with a function that circulates the temperature controlled liquid 30, and a filter 23 is also set up to filter the impurities in the liquid 30. 24 is a measuring instrument for measuring the refractive index of the liquid 30, 25 is an ultrasonic wave excitation apparatus installed for the purpose of preventing foam from adhering to the surface of the wafer 2 and the surface of the second optical element 7 to make the liquid 30 homogeneous, and 26 is the vibration insulating frame of the exposure apparatus.

[0019]

Next, the actual operation, actions, effects, etc. of the apparatus of the above configuration will be explained. When exposure is performed, first, a wafer 2 that has been coated in advance with a photosensitive material is taken out of the wafer cassette 10 by means of a wafer conveyance apparatus 11-1, and after it has been placed on the wafer position rough detection mechanism 11-2 (normally called a prealignment mechanism) and has undergone rough positioning, the wafer 2 is handled by a wafer feed hand 11-3, and the wafer 2 is set on the wafer chuck 12 installed in the chamber 9. The wafer 2 that has been placed on the wafer chuck 12 is secured by vacuum suction and undergoes surface correction. Simultaneously with this, the liquid 30 for immersion that is controlled at a constant temperature by a temperature control apparatus 21 is fed into the chamber 9 via a filter 23 by means of a transmission pump 22. When the liquid 30 reaches the prescribed amount, this is detected by the level gauge 19, and the pump 22 is stopped.

[0020]

The temperature of the liquid 30 is continually monitored by a temperature sensor 20, and when it has deviated from the prescribed temperature, the transmission pump 22 is again actuated, and liquid 30 at a constant temperature is circulated. At that time, flow



of liquid 30 resulting from circulation of the liquid 30 occurs, and the homogeneity of the liquid 30 is broken down, but measurement of homogeneity is also performed by a refractive index measurement apparatus 24. In addition, foam in the liquid 30, foam that has adhered to the surface of the wafer 2, and foam that has adhered to the surface of the second optical element 7 is removed by the actuation of an ultrasonic wave excitation apparatus 25. This ultrasonic wave excitation has the effect of making the liquid 30 itself homogeneous, and positioning and exposure of the wafer 2 is not affected because the amplitude of the vibration is small, and the frequency is high.

[0021]

When the homogeneity of the liquid 30 is checked by refractive index measurement apparatus 24, in the same way as a normal exposure apparatus, accurate positioning (alignment, focus, etc.) and exposure of the wafer 2 are performed. At this time, through the step and repeat operation, flow of the liquid 30 is generated, but because the interval between the second optical element 7 and the surface of the wafer 2 is approximately several mm to several tens of mm and the liquid 30 has viscosity, the flow of liquid 30 of this portion disappears in a relatively short time. Therefore, a delay period may be taken after the step for each shot or the flow status of the liquid 30 of this portion may be measured with the refractive index measurement apparatus 24 and the sequence continued at the point where the flow has stopped. In addition, since the periphery of the chamber 9 is covered by a heat insulating material 18, it is not normally necessary to actuate the transmission pump 22 and circulate liquid 30 at a constant temperature for approximately the time for processing of one wafer.

[0022]

When exposure of the entire surface of the wafer 2 is completed, the transmission pump 22 is activated again simultaneously with this, and it begins to expel the liquid 30 in the chamber 9. At this time, the level gauge 19 continually senses the height of the liquid 30, and at the point when the height of the liquid 30 has become slightly lower than the surface of the wafer chuck 12, the transmission pump is stopped. Therefore, the amount of expelled liquid 30 is slight. After this, the vacuum of the wafer chuck 12 is cut off, handling of the wafer 2 on the wafer chuck 12 is performed by a carry out hand 14, and it is placed in the wafer cassette 10. At this time, immediately before storage, both surfaces of the wafer 2 may be subjected to a flow of clean air to remove the liquid 30 from the surface of the wafer 2.

[0023]

#### Embodiment 2

Fig. 11 is a block diagram of an immersion type projection exposure apparatus relating to the second embodiment of the present invention, Fig. 12 is a cross sectional drawing of the wafer chuck 12 in Fig. 11, and Fig. 14 is a block diagram that shows a transformation example of the stage portion in Fig. 11. In these drawings, 31 is a conveyance port for carrying the wafer 2 into and out of the chamber 9, 32 is a fluid bearing guide for making movement of the fine movement stage 14 in the horizontal direction possible, 33 is a vacuum pump for reducing the pressure of the interior of the chamber 9 and removing foam in the liquid 30, 34 is a valve connected to the vacuum pump 33, 35 is a blower that has a nozzle for blowing clean air onto the surface of the wafer 2 to remove liquid 30, 36 is a pressure gauge for measuring the internal pressure of the chamber 9, and 37 is a shutter mechanism built into the wafer chuck. The other



configuration is the same as in the case of Fig. 1, but the seal 8 has a function of maintaining the airtightness of the chamber 9. Also, in addition to a function that circulates the liquid 30, the pump 22 is also equipped with a function that controls the pressure of the liquid 30.

[0024]

In this configuration, the point in which operation differs with the case of the first embodiment is that opening and closing of the conveyance port 31 is performed in the respective cases of conveying the wafer 2 into and carrying it out of the chamber 9. In addition, after the wafer 2 is set on the wafer chuck 12, the prescribed amount of liquid 30 has been filled, and the pump 22 has been stopped, a vacuum pump 33 that is connected to the vacuum chamber 9 is actuated, and foam in the liquid 30 is removed. At this time, simultaneously, the ultrasonic wave excitation apparatus 25 is actuated to remove foam in the liquid 30, foam that has adhered to the surface of the wafer 2, and foam that has adhered to the surface of the second optical element 7. When removal of the foam is completed, the vacuum pump 33 is stopped, the valve 34 connected thereto is simultaneously closed, and the pump 22 is actuated to begin pressurization of the liquid 30. Then, at the point when the pressure of the pressure gauge 36 that measures the internal pressure of the chamber 9 has indicated a prescribed value, in the same way as in the case of Embodiment 1, the temperature of the liquid 30 from the temperature sensor 20 is continually monitored. In addition, both sides of the wafer 2 are blown with clean air using a blower 35 immediately before placement in the wafer cassette 10, and the liquid 30 is removed from the surface of the wafer. Other operations are the same as in the case of Embodiment 1.

[0025]

Through this, since the liquid 30 is being pressurized, the flow of the liquid 30 resulting from the step and repeat operation disappears in a shorter period of time. In addition, it is also possible to increase the ability to correct the surface of the wafer 2 on the wafer chuck 12.

[0026]

#### Embodiment 3

Fig. 12 is a cross sectional drawing of the wafer chuck portion of an immersion type projection exposure apparatus relating to the third embodiment of the present invention. In the above, the liquid is flowed in and expelled for each wafer, but, here, as shown in Fig. 12, a shutter mechanism 37 is added to the wafer chuck 12, the shutter is opened and vacuum suction is performed only in the case in which the wafer 2 is on the wafer chuck 12, and processing can be performed even while the liquid 30 has been filled 30. Through this increases in throughput can be pursued. In such a case, the conveyed wafer 2 is inserted by means of a wafer feed hand 11-3 into the liquid 30 at an angle or vertically with respect to the liquid 30 so that foam does not remain, and it is set on the wafer chuck 12 after being made horizontal inside the liquid 30.

[0027]

#### Embodiment 4

Fig. 6 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the fourth embodiment of the present invention. This is such that, in the configuration of Embodiment 1, the drive system of the XY stage 13 is placed outside the chamber 9 to prevent impurities from being mixed



into the liquid 30. In this case, as shown in the same drawing, the entirety of the XY stage 13 is arranged outside the chamber 9, the chamber 9 is placed on top of the XY stage 13, and positioning is performed together with the chamber 9. In this case, since a step and repeat operation is performed on the entire liquid 30, the liquid 30 inside the chamber 9 flows according to the degree of acceleration during movement, so the structure is such that a stabilizer 29 that combines a plate in a mesh shape as shown in Fig. 7 is inserted into the liquid 30 at the time of the step, and the flow and waves of the liquid 30 are controlled. Note that it is possible to apply the same type of stage configuration to the configuration of Embodiment 2 as well. In addition, as shown in Fig. 13, the stabilizer 29 may be made into a shape in which a hole is provided at the center for passing through the projection lens 4.

[0028]

#### Embodiment 5

Fig. 8 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the fifth embodiment of the present invention. As shown in the configuration in Embodiment 1, this is configured in such a way that the drive system of the XY stage 13 is placed outside the chamber 9 in the same way as the case of Embodiment 4 to prevent impurities from mixing in with the liquid 30. However, in this case, as shown in the same figure, the configuration is such that the fine movement stage 14 within the chamber 9 is indirectly driven by arranging a magnet 27 on the bottom surface of the fine movement stage 14, forming the bottom surface of the chamber 9 using a material with permeability to magnetically bond it with the magnet 28 on the XY stage 13 on the bottom portion of the chamber 9, and moving the XY stage 13 with the bottom surface of the chamber 9 as the guide of the fine movement stage 14.

[0029]

#### Embodiment 6

Fig. 14 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the sixth embodiment of the present invention. As shown in the configuration in Embodiment 2, it is configured so that the fine movement stage 14 within the chamber 9 is indirectly driven by placing the drive system of the XY stage 13 outside the chamber 9 in the same way as the case of Embodiment 5 to prevent impurities from mixing in with the liquid 30, arranging a magnet 27 on the bottom surface of the fine movement stage 14, forming the bottom surface of the chamber 9 using a material with permeability to magnetically bond it with the magnet 28 on the XY stage 13 on the bottom portion of the chamber 9, and moving the XY stage 13 with the bottom surface of the chamber 9 as the guide of the fine movement stage 14. Also, in addition, a nozzle that blows out liquid is provided on the lower surface of the fine movement stage 14, and a fluid bearing guide 32 is formed so that the liquid 30 used in immersion is blown out from there. Through this, it is possible to lighten the mass of the movable portion during the step and repeat operation, so it is possible to further increase throughput.

[0030]

#### Embodiment 7

Fig. 9 is a cross sectional drawing that shows the stage portion of an immersion type projection exposure apparatus relating to the seventh embodiment of the present invention. This is such that only the portion that includes the wafer chuck 12 is arranged



in the chamber 9 or the wafer chuck 12 is directly formed on the bottom surface of the chamber 9, and the chamber 9 is arranged on the fine movement stage 14. In this case, these are formed by a low heat expansion material so that the bottom surface of the chamber 9 and the two surfaces that are adjacent thereto are respectively at right angles, and it is also possible to make these two surfaces the reference surfaces for the laser interferometer 15 measurements.

[0031]

Note that, in the above respective embodiments, it is also possible to configure the conveyance apparatus for carrying the wafer onto the wafer chuck 12 or carrying the wafer out from on top of the chuck 12 both inside the chamber 9 and outside the chamber 9.

[0032]

#### Effects of the Invention

As explained above, through the present invention, it is possible to apply an immersion method that increases resolution and depth of focus to an exposure apparatus in a condition in which it can be thoroughly utilized in actual manufacturing processes. Therefore, it is possible to provide an immersion type exposure apparatus that is low in cost and with which effects that correspond to the respective wavelengths can be expected at any wavelength no matter what the wavelength of the exposure light source, be it a g-ray, and i-ray or an excimer laser, and to further provide an immersion type exposure apparatus that is able to utilize conventional process technologies.

#### Brief Description of the Drawings

Fig. 1

Fig. 1 is a block diagram that shows the configuration of an immersion type projection exposure apparatus relating to the first embodiment of the present invention.

Fig. 2

Fig. 2 is a cross sectional view of the optical element applied to the apparatus of Fig. 1.

Fig. 3

Fig. 3 is a cross sectional view of another optical element applied to the apparatus of Fig. 1.

Fig. 4

Fig. 4 is a cross sectional view of yet another optical element \*\* applied to the apparatus of Fig. 1.

Fig. 5

Fig. 5 is a cross sectional view that shows the case in which a laser interferometer is directly attached to the side surface of the chamber in the apparatus of Fig. 1.

Fig. 6

Fig. 6 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the fourth embodiment of the present invention.

Fig. 7

Fig. 7 is an oblique view of a stabilizer applied to the apparatus of Fig. 6.

Fig. 8

Fig. 8 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the fifth embodiment of the present invention.

Fig. 9



Fig. 9 is a cross sectional view that shows the stage portion of an immersion type exposure apparatus relating to the seventh embodiment of the present invention.

Fig. 10

Fig. 10 is a cross sectional view for explaining the immersion effect.

Fig. 11

Fig. 11 is a block diagram of an immersion type projection exposure apparatus relating to the second embodiment of the present invention.

Fig. 12

Fig. 12 is a cross sectional view of the wafer chuck in Fig. 11.

Fig. 13

Fig. 13 is an oblique view of a stabilizer applied to the apparatus of Fig. 14.

Fig. 14

Fig. 14 is a schematic view that shows a transformation example of the stage portion in Fig. 11.

Explanation of Codes

1: reticle, 2: wafer, 3: illumination optical system, 4: projection optical system, 5: reticle stage, 6: alignment optical system, 7: optical element, 8: seal, 9: liquid tank, 10: wafer cassette, 12: wafer chuck, 11-1 through 11-4: rough positioning apparatus, 13: XY stage, 14: fine movement stage, 15: laser interferometer, 16: reference mirror, 17: window, 18: heat insulation material, 19: level gauge, 20: temperature gauge, 21: temperature controller, 22: pump, 23: filter, 24: measuring equipment, 25: ultrasonic wave excitation apparatus, 26: vibration insulating frame, 27, 28: magnet, 29: stabilizer, 30: liquid, 31: conveyance port, 32: fluid bearing guide, 33: vacuum pump, 34: valve, 35: blower, 36 pressure gauge, and 37: shutter mechanism.

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 7

Fig. 12

Fig. 1

Fig. 6

Fig. 8

Fig. 11

Fig. 9



Fig. 10

Fig. 13

Fig. 14